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REPORT ON METHODS FOR MAPLE PRODUCTS

ESTABLISHING NARROWER LIMITS FOR CONDUCTIVITY VALUES

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To determine the purity of a sample of maple sirup, the following determinations must be made: total solids, conductivity, soluble and insoluble ash, alkalinity of insoluble ash, alkalinity of total ash, lead number, and malic acid values (see *Official Methods of Analysis*, 8th Ed., 1955, pp. 561–563).

Because of the time required to perform all of these tests on even a single sample, it becomes nearly impossible to test all of the samples collected by a State or Federal inspection agency or by the chemists of large sirup-processing companies. The general practice is to determine conductivity value and perhaps make one or two other tests. Conductivity is used as an indication of purity because sucrose—the usual adulterant for maple sirup—tends to give the sirup an abnormally low conductivity value.

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The conductivity values for maple sirups vary according to the amounts of salts and organic acids that the sirups contain. These contents, in turn, vary with different seasons and with the methods used in handling the sap and in processing the sirup. The range of conductivity values for authentic pure maple sirups (110 to 230) has become so wide that conductivity is now practically worthless as an index of adulteration.

While it is recognized that samples of authentic pure maple sirups occasionally have conductivity values as low as 110 or as high as 230, the values for the majority of samples are well within this range. Further, if the conductivity values of a representative number of maple sirups were of a normal population, relatively narrow limits of values could be established so as to include all samples about whose purity there could be little doubt.

To test this hypothesis and to determine whether or not it is possible to establish narrower limits, the conductivity values of a large number of maple sirups had to be determined. Two such sets of values have been obtained. Dr. Arthur Wendt of the Fred Fear Company supplied 341 values that represented three grades of sirup (U. S. grades AA and A combined, U. S. grade B, and U. S. grade unclassified) collected from 1950 through 1955. These samples were not authenticated; however, it can be reasonably assumed that they were pure. The other set, consisting of 137 conductivity values, was supplied by the Quebec Department of Agriculture, through the courtesy of Dr. G. Vallières. These samples were authentic pure maple sirups representing the same grades as those in the first set; they were obtained from 1943 through 1955.

If it could be assumed that the conductivity values in the two sets of data were representative of a normal population, the values could be separated, by prescribed calculation, into smaller groups with arbitrarily defined limits. One such method is the use of standard deviations with areas defined by $\bar{x} \pm s$ and $\bar{x} \pm 2s$ of the means. The area encompassed by $\bar{x} \pm s$ should contain two-thirds of the values and should also include conductivity values of those maple sirup samples whose purity can be accepted with practically no cause for doubt. The area defined by $\bar{x} \pm 2s$ would include 95 per cent of the values. There would be little doubt of the purity of those samples within the $\bar{x} \pm 2s$ area but outside the $\bar{x} \pm s$ area.

In Tables 1 and 2, the data of the two sets of conductivity values have been treated statistically; n is the number of conductivity values (number of samples), range is the upper and lower conductivity values included in n, $\bar{x}$ is the average or mean of the conductivity values in population n, and s is the standard deviation.

Table 1 shows that the mean (133) is nearly constant for the two sets of values and for the combination of the two sets. The standard deviation for the 341 American samples was 12, and for the combined sets (478

TABLE 1.—*Conductivity values of maple sirup samples*

SAMPLES	n	RANGE	$\bar{x}$	s	$\bar{x}\pm s$		$\bar{x}\pm 2s$	
					RANGE	% POP.	RANGE	% POP.
Set 1 (American)	341	105–161	132.9	12.0	121–145	66.9	109–157	96.5
Set 2 (Canadian)	137	113–187	133.1	14.1	119–147	78.8	105–161	95.6
Combined sets 1 and 2	478	105–187	132.9	12.5	120–145	68.0	108–158	96.9

TABLE 2.—*Conductivity values of maple sirup samples of different grades*

GRADE OF SAMPLES	n	RANGE	$\bar{x}$	s	$\bar{x}\pm s$		$\bar{x}\pm 2s$	
					RANGE	% POP.	RANGE	% POP.
Set 1, 341 samples								
U.S. AA+A	72	105–158	121.0	8.9	112–130	79.2	103–139	95.8
U.S. B	82	108–161	128.3	7.6	121–136	81.7	113–144	92.7
U.S. Unclassified	187	111–160	139.4	10.1	129–149	69.0	119–160	94.7
Set 2, 125 samples								
Can. AA+A	100	118–177	130.8	11.0	120–142	76.0	109–153	97.0
Can. B	13	135–170	148.3	9.2	139–157	69.2	130–166	92.3
Can. C	12	113–171	130.3	18.3	112–148	83.3	94–167	91.7
Combined Sets 1 and 2, 466 samples								
U.S. and Can. AA+A	172	105–177	127.0	11.2	116–138	75.6	104–149	94.2
U.S. and Can. B	95	108–170	132.0	10.4	121–142	81.1	111–153	92.6
U.S. Unclassified and Can. C	199	111–171	139.0	10.9	128–150	70.9	117–161	93.5

samples) it was 12.5. The slightly higher standard deviation (14.1) for Set 2 (Canadian) can be explained on the basis of the unequal distribution of the samples among the different grades.

The samples in Set 1 and in the combination of Sets 1 and 2 are fairly representative of a normal population, since $\bar{x}\pm s$ includes 67 per cent and 68 per cent of the population and $\bar{x}\pm 2s$ includes 96.5 per cent and 96.9 per cent of the population.

The range of the values encompassed by $\bar{x}\pm s$ is from 120 to 145. Any

sirup of a standard density whose conductivity falls within this range is pure.

The second group of conductivity values defined by $\bar{x} \pm 2s$ includes those values from a minimum of 108 to a maximum of 158 except the values included by $\bar{x} \pm s$. Any value within this group would be considered presumptive, i.e., all samples with conductivity values from 108 to 120 and from 145 to 158 are presumed to be pure unless some other circumstance indicates otherwise.

The third group would include all conductivity values not included in $\bar{x} \pm 2s$, that is, less than 108 or more than 158. Any conductivity values in this group would indicate the sirup to be of doubtful purity, i.e., the maple sirup is presumed to be impure unless proved to be pure by other tests and circumstances.

The grouping of the conductivity values of all maple sirup into these three groups, irrespective of the sirup grade, may result in inconsistencies, since it is known that different grades of sirup have different acid and salt contents, both of which affect their conductivity values.

The data for Sets 1 and 2 were therefore separated according to the grades (color) of the sirup. These grades are as follows:

Can. AA, US AA (N. Y. Fancy, Vt. Fancy)
Can. A, US A (N. Y. No. 1, Vt. A)
Can. B, US B (N. Y. No. 2, Vt. B)
Can. C, US Unclassified (N. Y. No. 3, Vt. C)

The data for the two sets of conductivity values grouped according to the grades of the sirup are given in Table 2. The upper two grades, AA and A, have been combined in this statistical treatment in view of present practices. The data, when grouped, approximate those of a normal population as shown by the percentage of the conductivity values which are within the $\bar{x} \pm s$ and $\bar{x} \pm 2s$ areas. Those included in the $\bar{x} \pm 2s$ represent approximately 95 per cent of the values.

Table 2 shows that the values (range) within $\bar{x} \pm s$ and $\bar{x} \pm 2s$ are different for the different grades. To determine whether or not these differences are significant, a "t" test was made. The results are given in Table 3. Since the "t" test shows a significant difference in the mean value, $\bar{x}$, of the conductivity values for the three grades of sirup even at the one per cent level, a different range of conductivity values must be established for each grade of sirup.

Table 4 shows the three arbitrary ranges of conductivity values as defined by $\bar{x} \pm s$, $\bar{x} \pm 2s$, and those outside of $\bar{x} \pm 2s$, for the different grades of sirup. These ranges of values are designated as acceptable, presumptive, and doubtful. Conductivity values of sirup within the acceptable range ($\bar{x} \pm s$) establish reasonable proof of purity. Sirups with conductivity values within either the high or low presumptive ranges (between $\bar{x} \pm s$ and $\bar{x} \pm 2s$) are presumed to be pure unless suspected to be otherwise from

TABLE 3.—*Significance of difference between the means of conductivity values of sirups of different grades*

COMPARISONS	CALCULATED t	t VALUE (TABLE)	
		5% LEVEL	1% LEVEL
U.S. AA+A *vs.* U.S. B	5.5	2.0	2.6
U.S. B *vs.* U.S. Unclassified	8.9	2.0	2.6
U.S. AA, A, Can. AA, A *vs.* U.S. B, Can. B	3.5	2.0	2.6
U.S. B, Can. B *vs.* U.S. Unclassified, Can. C	5.4	2.0	2.6

TABLE 4.—*Range of conductivity values for different grades of maple sirup*

GRADE	ACCEPTABLE RANGE ($\bar{x} \pm s$)	PURITY OF SIRUPS			
		PRESUMPTIVE RANGE		DOUBTFUL	
		LOW ($\bar{x}-s$ to $\bar{x}-2s$)	HIGH ($\bar{x}+s$ to $\bar{x}+2s$)	(BELOW $\bar{x}-2s$)	(ABOVE $\bar{x}+2s$)
U.S. AA and A Can. AA and A	116–138	104–116	138–149	104	149
U.S. B Can. B	121–142	111–121	142–153	111	153
U.S. Unclassified Can. C	128–150	117–128	150–161	117	161

available information. Sirups with conductivity values in the doubtful range (above or below $\bar{x} \pm 2s$) for any of the grades of sirup indicate that the purity of the sirup is doubtful and that further tests must be made and additional information obtained before the sample can be accepted as pure.

It is recommended* that the nine ranges of conductivity values (Table 4) for the different grades of maple sirup be accepted as guides for the purity of maple sirups instead of the current wide range for all maple sirups.

* For report of Subcommittee D and action of the Association, see *This Journal*, 40, 38, 39 (1957).